2010

Datasets of odontocete sounds annotated for developing automatic detection methods

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NPS-OC-10-005CR

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

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by

David K. Mellinger

December 2010

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Prepared for: CNO(N45), Washington, D.C.

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This report was prepared for and funded by the Chief of Naval Operations [CNO(N45)], Washington, D.C. The report was prepared by Oregon State University supported under NPS Grant N00244-08-1-0029.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
December 2010	Technical Report	1 October 2007-30 September 2008

4. TITLE AND SUBTITLE
Datasets of odontocete sounds annotated for developing automatic detection methods

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00244-08-1-0029

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
David K. Mellinger

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Oregon State University
Newport, Oregon 97365

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Sponsoring Agency: Chief of Naval Operations (N45), Washington, D.C.
Monitoring Agency: Dept. of Oceanography, Naval Postgraduate School, Monterey, CA

10. SPONSOR/MONITOR'S ACRONYM(S)
Sponsoring Agency: CNO (N45)
Monitoring Agency: NPS

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
NPS-OC-10-005CR

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES The views expressed in this reports are those of the authors and do not reflect the official policy or position of the Department of Defense or the US Government.

14. ABSTRACT
Environmental laws now require marine research and operations to be conducted so as to minimize impacts on marine mammals and mitigate any adverse impacts caused by that research/operation. Acoustic techniques have become the primary tool used for this task, and have produced vast quantities of data. Automatic call detection software has rapidly become the method of choice for analyzing these data.
Most methods for detecting and classifying animal sounds in marine science have been developed for low frequency sounds of baleen whales. However, it is odontocetes (especially beaked whales) that have been most affected by marine operations, particularly of the U. S. Navy, and are of greatest public concern. Therefore, development of high-performance automatic detection methods for odontocetes is now imperative. This report chronicles the progress of this project to collect recordings of beaked whales and other marine mammal species; to annotate these sound files to make them useful to researchers working on automatic call detection and classification; to make the sound files publicly available in an archive on the Internet ("MobySound"); and to develop and test automatic detection algorithms and software, particularly software for autonomous ocean sensing systems such as gliders.

15. SUBJECT TERMS
Marine mammals, animal sound recordings, acoustics, MobySound, odontocetes, beaked whales, acoustic archive.

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
					Tarry Rago
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	UU	34	831-656-3349

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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Contents

Datasets of odontocete sounds annotated for developing automatic detection methods

Report submitted pursuant to award number **N00244-08-1-0029**

Prepared September, 2010

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Project Overview

The Navy is required by environmental laws, including the Endangered Species Act, the Marine Mammal Protection Act, and the National Environmental Policy Act, to conduct its research and operations with minimal impacts on marine mammals, and to mitigate any adverse impacts caused by those transactions. In compliance, the Navy has been compelled to monitor the occurrence and behavior of marine mammals before, during, and after research and operational activities. Acoustic methods have become a primary tool used for this task; they are now routinely and widely used in marine mammal research, monitoring, and mitigation.

This popularity is due to the advantages provided by acoustic methods in detecting animals underwater, operating at night and in poor weather, recording target signals in real time, and post-processing acoustic data. Acoustic signals used for marine mammal studies are typically either recordings made by autonomous hydrophones [Worcester *et al.* 1995; Fox *et al.* 2001; Clark *et al.* 2002], shore-cabled hydrophones or hydrophone arrays, both military and civilian [Costa 1993; Nishimura and Conlon 1994; Clark 1994; Vents 2005], or sounds captured in real time from towed arrays or expendable sonobuoys during ship-based surveys [e.g., Barlow and Taylor 2005].

Equipment for capturing acoustic data is becoming increasingly widespread due to advances in technology and decreases in cost; advancements in hardware and especially software have produced vast improvements in detecting and collecting acoustic signals from marine mammals. Data collection now often outpaces the analysis abilities of many of those collecting it. Automatic call detection software that detects and classifies animal sounds is rapidly becoming the method of choice for analyzing this glut of acoustic data. Automatic detectors process real-time or recorded data and find times when calls of interest occur. (Here, "call" is used in a generic sense to mean sound produced by an animal, rather than in the narrower technical interpretation used in animal behavior research.)

Most methods for detecting and classifying animal sounds in marine sciences have been developed for low-frequency sounds of baleen whales. Although this has been useful, baleen whales comprise only a small fraction of all cetaceans - 14 known species out of a total of roughly 85 - and an even smaller fraction of all marine mammals. In addition, the issues of greatest public concern, and greatest possible impact on Navy operations, center on the threat to odontocetes, especially beaked whales. Beaked whales - members of the family *Ziphiidae*, including the genera *Mesoplodon*, *Ziphius*, *Hyperoodon*, *Berardius*, and others - have stranded in places and times associated with Naval sonar use [Frantzis 1998; NMFS 2001; Fernández *et al.* 2005; Aguilar de Soto *et al.* 2006], and have attracted intense interest from management agencies, conservation organizations, and the public. For these reasons, it is incumbent on the Navy to detect odontocetes in general, and beaked whales in particular, when performing research, training and readiness exercises, ship shock trials, and other activities potentially disruptive to these species. Development of high-performing automatic detection methods for beaked whales and other odontocetes is now imperative.

To further the development of detection methods for odontocetes, it is helpful to have standardized training and testing datasets. Such datasets have been used widely in the automatic

speech recognition (ASR) research community [e.g., DARPA 1990, Garofolo *et al.* 1991, Hirsch and Pearce 2000], as they provide a consistent benchmark on which to test and compare recognition methods. An analogous dataset for use in odontocete call detection research would assist the field in much the same way. Preliminary efforts to build such datasets for baleen whale detection have been made [Mellinger and Clark 2006; Desharnais *et al.* 2004], but before this project no datasets were widely used for odontocete sounds.

The aims of this project were to collect recordings of beaked whales and other marine mammal species, annotate these sound files to make them useful to researchers working on automatic call detection and classification, and make them publicly available in an archive on the Internet; and develop and test automatic detection algorithms and software, particularly software for autonomous ocean sensing systems such as gliders.

In more detail, project tasks were as follows:

(A) Identify any new beaked whale recordings, and solicit contributions to the archive.

(B) Collect the above recordings from researchers.

(C) Annotate recordings and make the recordings and metadata available on the web.

(D) Identify recordings of click sounds of other odontocete species.

(E) Obtain the recordings listed in task D.

(F) Annotate the recordings obtained in task D.

(G) Identify and collect other annotated marine mammal recordings to add to the archive.

(H) Develop methods to detect and classify the clicks of odontocete species.

(I) Disseminate: Prepare and submit article(s) for publication in scientific journals. In addition, present the results of this work at scientific conferences and other meetings.

Results/Milestones

The results/milestones by task are as follows:

(A) **Idenitfy new beaked whale recordings.** This has been an on-going effort since the start of this project. 14 recordings were found, collected, and annotated; these are listed in Task B and C just below. The table of extant un-annotated beaked whale recordings available to be added to the archive is included as Appendix 1. In addition, the website for the MobySound archive hosts the datasets for the International Workshops on Detection, Classification, and Localization of Marine Mammals using Passive Acoustics, of which there have been four to date. The third and fourth of these workshops (held in 2007 in Boston, USA, and 2009 in Pavia, Italy) focused on beaked whales.

(B,C) **Collect and annotate beaked whale recording**s. This was done, and recordings from four species of beaked whales are now in the archive. All collected recordings were annotated to indicate the locations of calls of interest in the respective data sets. Appendix 1 lists the annotated recordings; the four beaked whale species are Cuvier´s (*Ziphius cavirostris*), Blainville's (*Mesoplodon densirostris*), Baird's (*Berardius bairdii)*, and Arnoux's *(Berardius arnuxii)*. These are now represented by a total of 134 files of acoustic data, comprising 25 hours; with a total of 13,153 annotated echolocation clicks. We are currently working on an analysis of acoustic glider data (collected in Hawaii and AUTEC). The results of this analysis will provide new high-quality beaked whale data sets for the MobySound.org archive.

(D) **Identify other odontocete recordings.** This has been an on-going effort since the start of this project. The table of extant recordings of other odontocetes available to be added to the archive is included as Appendix 1.

(E,F) **Collect and annotate recording of other odontocetes.** This was done, and recordings from 6 new odontocete species are now available in the archive. This includes data for the 5th International Workshop on Detection and Localization Methods, which will focus on odontocete whistle contours and clicks. The majority of the annotations for this data set was made during this project, but not all; the data set will be made public when annotation is complete, probably in October 2010. Appendix 1 shows these recordings; new odontocete species are melon-headed whale (*Peponocephala electra),* false killer whale *(Pseudorca crassidens*), pantropical spotted dolphin *(Stenella attenuata*), striped dolphin (*Stenella coeruleoalba*), spinner dolphin (*Stenella longirostris*), and bottlenose dolphin (*Tursiops truncatus*). New recordings for species already in the archive but from other ocean basins were collected for long-finned pilot whale (*Globicephala malaena*), Risso's dolphin (*Grampus griseus*), sperm whale (*Physeter macrocephalus),*and rough-toothed dolphin (*Steno bredanensis*). The total number of non-beaked-whale odontocete species is currently 12, represented by 154 files comprising 12 hours of acoustic data with 5593 annotated signals.

(G) **Identify and collect other annotated marine mammal recordings to add to the archive.** Three species of pinnipeds are now in the archive: crabeater seal (*Lobodon carcinophaga*), leopard seal (*Hydrurga leptonyx*), and bearded seal (*Erignathus barbatus*), represented by 3941 files comprising 37 hours of acoustic data with 7,249 annotated signals.

(H) **Develop new detection and classification algorithms.** Research associate Dr. Holger Klinck is working on the development of new detection, classification, and density estimation methods, applying them for monitoring and mitigation tasks. He and Dr. Mellinger developed a method known as Energy Ratio Mapping Algorithm (ERMA) for detecting clicks of beaked whales and other odontocetes of interest. ERMA has been presented at several conferences and meetings and a manuscript is currently in review. This detection method has been successfully used for real-time detection of Cuvier´s (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales using passive-acoustic gliders and floats (QUEphone) off the Kona Coast of the Big Island of Hawaii, and at AUTEC in the Bahamas. These test trials allowed refinements to ERMA and an increase in detection performance. Current efforts focus on implementing the detection algorithm on a DMON (M. Johnson, WHOI). Dr.

Klinck is working on another ERMA modification that will enable detection of harbor (*Phocoena phocoena*) and Dall's (*Phocoenoides dalli*) porpoises. This detector will be used in the scope of a harbor porpoise survey testing an autonomous acoustic sailboat (*AAS Endurance*) in the Baltic Sea in summer 2011.

Drs. Mellinger and Klinck are also developing a technique based on Gaussian mixture models (GMMs) for classifying odontocete echolocation clicks, in collaboration with Dr. Marie A. Roch (SDSU and UCSD, Scripps Institute of Oceanography). The classification uses data from 5 dolphin species and 1 beaked whale species. The principal goal is to develop a classification system which distinguishes dolphin echolocation clicks from beaked whale clicks. The current classifier correctly distinguishes approximately 75% of the echolocation clicks in this six-species mix; its success rate at distinguishing beaked whale clicks from other odontocetes is approximately 90%. A manuscript describing the classification system has been accepted for publication in the Journal of the Acoustical Society of America. Current efforts focus on the implementation of a C version of the classifier on the Seaglider and on the QUEphone. The combined detection/classification method will help to boost the overall performance of the system and to reduce the false positive alarms to an absolute minimum, a necessity for use during Navy exercises.

Dr. Klinck also developed an algorithm to estimate the density of leopard seals (*Hydrurga leptonyx*) using single hydrophone data, in collaboration with Dr. Tracey Rogers and Nadine Constantinou at the University of New South Wales, Sydney, Australia. The methodology allows analysis of continuous long-term data sets (years of data) efficiently in a few days and to extract the density of leopard seals. This application of this technique for odontocete species may be of use to the Navy.

(I) **Dissemination.** The MobySound archive at www.mobysound.org. has been accessed increasingly more often since being moved to a new host. The website has had more than 1000 unique visitors from January through September 2010. The top 25 countries that used the site were (ranked by usage) USA, Russia, Canada, France, un-defined European country, Romania, China , UK, Germany, Australia, Spain, Ukraine, Switzerland, Brazil, New Zealand, Finland, Puerto Rico, Italy, Netherlands, Japan, Greece, Portugal, South Africa, Austria, and Slovenia. An image of the current front page of this website is shown in Appendix 2. Dr. Klinck also set up a website for the 5th International Workshop on Detection and Localization Methods, which will be posted at latest by the end of October 2010.

Several students received training in acoustic data analysis under the supervision of Dr. Klinck: Nadine Constantinou (Australia), Cornelia Kreiss (Germany), Andrea Capurro (Argentina), and Anna-Maria Seibert (Germany). This has produced one collaborative research article which has been submitted to Marine Mammal Science, and three collaborative articles which are currently in preparation.

In addition, a number of journal papers and presentations about this project, and using recordings from this project, have been published or are in preparation. The list below includes only the most recent publications from 2009, 2010, or 'in prep'. Appendix 3

provides a comprehensive list of publications, internal reports, presentations and posters, and data exchanges.

Bogue, N. M., J. C. Luby, W. A. Jump, J. M. Pyle, G. B. Shilling, T. Litchendorf, A. S. Wood, D. K. Mellinger, H. Klinck. **2009**. Passive acoustic monitoring using Seaglider: initial deployments. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 52-53*.

Klinck, H. and D. K. Mellinger. **In review**. The Energy Ratio Mapping Algorithm (ERMA): a tool to improve the energy-based detection of odontocete clicks. *Submitted to:* Journal of the Acoustical Society of America.

Klinck, H., and D. K. Mellinger. **2009**. A real-time detection system for odontocete echolocation clicks in the low-energy processing environment of an acoustic glider. J. Acoust. Soc. Am. **125(4)**: *2548(A)*.

Klinck, H., D. K. Mellinger, N. M. Bogue, J. C. Luby, W. A. Jump, J. M. Pyle, and G. B. Shilling. **2009**. Autonomous passive acoustic monitoring of marine mammals using the Seaglider: onboard real-time detection and classification of target signals. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *p. 86*.

Klinck, H., D. K. Mellinger, K. Klinck, J. Hager, L. Kindermann, and O. Boebel. **2010**. Long-range underwater vocalizations of the crabeater seal (*Lobodon carcinophaga*). Journal of the Acoustical Society of America **128**: *474-479*.

Klinck, H., R. Stelzer, K. Jafarmadar, and D. K. Mellinger. **2009**. AAS Endurance: An Autonomous acoustic sailboat for marine mammal research. Proceedings of the International Robotic Sailing Conference (IRSC). Matosinhos, Portugal, July 2009, *pp. 43-48*.

Kreiss, C. M., I. C. Van Opzeeland, H. Klinck, H. Bornemann, L. Kindermann, H. Figueroa, T. L. Rogers, J. Ploetz, and O. Boebel. **In review**. Leopard seal (*Hydrurga leptonyx*) vocalizations from three different Antarctic locations. *Submitted to*: Marine Mammal Science.

Küsel, E.T., D. K. Mellinger, L. Thomas, T. A. Marques, D. Moretti, and J. Ward. **In prep**. Development of method for cetacean density estimation from single fixed sensors using passive acoustics.

Matsumoto, H., C. D. Jones, D. K. Mellinger, and R. P. Dziak. **2009**. Acoustic float for marine mammal monitoring. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 70-71*.

Mellinger, D. K. **2009**. Automatic detection for long-term monitoring of marine organisms. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 54-55*.

Mellinger, D. K., D. Gillespie, C. Clark, and A. Thode. **2009**. Signal processing overview. *Presentation Abstracts*: Acoustic Monitoring and Mitigation Systems: Status and Applications for Use by Regulated Offshore Industries. Minerals Management Service, Nov. 17-19, 2009, Boston, *pp 14-15*.

Mellinger, D. K., D. Gillespie, H. Figueroa, K. Stafford, and T. Yack. **2009**. Software for bioacoustic analysis of passive acoustic data. J. Acoust. Soc. Am. **125(4)**: *2547(A)*.

Mellinger, D. K., H. Klinck, N. M. Bogue, J. C. Luby, W. A. Jump, J. M. Pyle, G. B. Shilling, T. Litchendorf, and A. S. Wood. **2010**. Ocean gliders for acoustic observation of marine mammals. Abstract **BO44B-01**, Ocean Sciences Meeting, Portland, Feb. 22-26, 2010.

Mellinger, D. K., S. W. Martin, J. Yosco, R. P. Morrissey, N. A. DiMarzio, D. J. Moretti, and L. Thomas. **2009**. An algorithm for detection of whistles, moans, and other tonal sounds. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 48*.

Mellinger, D. K., R. P. Morrissey, S. W. Martin, L. Thomas, T. A. Marques, and J. Yosco. **In prep**. A method for detecting whistles, moans, and other frequency contours. *Submitted to*: J. Acoust. Soc. Am.

Morrissey, R. P., N. A. DiMarzio, D. J. Moretti, S. W. Martin, D. K. Mellinger, J. Yosco, C. Ciminello, and L. Thomas. **2009**. Passive acoustic detection of Minke whales (*Balaenoptera acutorostrata*) off the West Coast of Kauai, HI. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 57*.

Roch, M., Y. Barkley, S. Baumann-Pickering, J. A. Hildebrand, P. Hursky, H. Klinck, D. K. Mellinger, B. Patel, M. Porter, S. Qui, S. Rankin, M. Soldevilla, and S. M. Wiggins. **2009**. Acoustic detections and how to manage them. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 62-63*.

Roch, M. A., H. Klinck, S. Baumann-Pickering, D. K. Mellinger, S. Qui, M. S. Soldevilla, and J. A. Hildebrand. **In prep**. Classification of echolocation clicks from odontocetes in the Southern California Bight. *Submitted to*: J. Acoust. Soc. Am.

Roch, M. A., H. Klinck, D. K. Mellinger, S. Baumann-Pickering, M. S. Soldevilla, M. McDonald, and J. A. Hildebrand. **In press**. Classification of odontocetes in the Southern California Bight through the use of echolocation clicks. *In press*: Journal of the Acoustical Society of America.

Stafford, K. M., S. E. Moore, P. J. Stabeno, D. V. Holliday, J. M. Napp, and D. K. Mellinger. **In press**. Biophysical ocean observation in the southeastern Bering Sea. *In press*: Geophys. Rev. Lett.

Van Opzeeland, I., S. Van Parijs, H. Bornemann, S. Frickenhaus, L. Kindermann, H. Klinck, J. Plötz, and O. Boebel. **2010**. Acoustic ecology of Antarctic pinnipeds. Marine Ecology Progress Series **414**: *267-291*.

Yack, T. M., J. Barlow, M. A. Roch, H. Klinck, S. Martin, D. K. Mellinger, and D. Gillespie. **2010**. Comparison of beaked whale detection algorithms. Applied Acoustics **71**:*1043-1049*.

References

Aguilar de Soto, N., M. Johnson, P. T. Madsen, P. L. Tyack, A. Bocconcelli, and J. F. Borsani. **2006**. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? Mar. Mamm. Sci. **22**:*690-699*.

Barlow, J., and B. L. Taylor. **2005**. Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. Mar. Mamm. Sci. **21**:*429-445*.

Clark, C. W. **1994**. Application of U.S. Navy underwater hydrophone arrays for scientific research on whales. *In*: Scientific Report, International Whaling Commission **44**, *pp. 1-12*.

Clark, C. W., F. Borsani, and G. Notarbartolo di Sciara. **2002**. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. Mar. Mamm. Sci. **18**:*286-295*.

Costa, D. P. **1993**. The secret life of marine mammals: novel tools for studying their behavior and biology at sea. Oceanography **6(3)**:*120-128*.

DARPA. **1990**. The DARPA TIMIT acoustic-phonetic continuous speech corpus. Technical Report **PB91-505065**, National Inst. Standards Tech., Gaithersburg, MD.

Desharnais, F., M. H. Laurinolli, D. J. Schillinger, and A. E. Hay. **2004**. A description of the workshop datasets. Can. Acoust. **32**:*33-38*.

Fernández, A., J. F. Edwards, F. Rodríguez, A. E. d. l. Monteros, P. Herráez, P. Castro, J. R. Jaber, V. Martín, and M. Arbelo. **2005**. ``Gas and Fat Embolic Syndrome'' involving a mass stranding of beaked whales (family *Ziphiidae*) exposed to anthropogenic sonar signals. Veterinary Pathology **42**:*446-457*.

Fox, C. G., H. Matsumoto, and T. K. A. Lau. **2001**. Monitoring Pacific Ocean seismicity from an autonomous hydrophone array. J. Geophysical Res. **106(B3)**:*4183-4206*.

Frantzis, A. **1998**. Does acoustic testing strand whales? Nature **392**:*29*.

Garofolo, J. S., L. F. Lamel, W. M. Fisher, J. G. Fiscus, D. S. Pallett, and N. L. Dahlgren. **1991**. The DARPA TIMIT acoustic-phonetic continuous speech corpus on CDROM. Technical Report PB91-100354, National Inst. Standards Tech., Gaithersburg, MD.

Hirsch, H. G., and D. Pearce. **2000**. The AURORA experimental framework for the performance evaluations of speech recognition systems under noisy condidions. ISCA ITRW Workshop “Automatic Speech Recognition: Challenges for the Next Millennium,” Paris, Sept. 2000.

Mellinger, D. K., and C. W. Clark. **2006**. MobySound: A reference archive for studying automatic recognition of marine mammal sounds. Applied Acoustics **67**:*1226-1242*.

Nishimura, C. E., and D. M. Conlon. **1994**. IUSS Dual Use: Monitoring whales and earthquakes using SOSUS. Mar. Tech. Soc. J. **27(4)**:*13-21*.

NMFS. **2001**. Bahamas Marine Mammal Stranding Event of 15-16 March 2000. Joint Interim Report, National Mar. Fisheries Service, Washington, DC.

Vents 2005. Acoustic monitoring program: Pioneer Seamount. *Web site* http://www.pmel.noaa.gov/vents/acoustics/pioneer.html, NOAA/PMEL Vents Program.

Worcester, P. F., K. R. Hardy, D. Horwitt, and D. A. Peckham. **1995**. A deep ocean data recovery module. IEEE Oceans '95 Proc., *pp. 1225-1231*.

Appendix 1:

Status summary of recordings in or available to the archive.

Entries with a number in the "N sounds" column have been annotated and are in the archive; those without a number have been acquired and are in the process of being annotated, or will be annotated, and added to the archive.

Species	Common Name	Region	N sounds	N files	N (s)	Source
CURRENT						
Mysticetes (baleen whales)						
Balaena mysticetus	bowhead whale	northern Alaska	589	128	3580	NOAA/CIMRS
		northeastern Alaska		45	2500	Greenridge Sciences, Inc.
		northwestern Alaska		9	18313	JASCO
Balaenoptera acutorostrata	Minke whale	north Atlantic	178	5	13185	NOAA/CIMRS
		western tropical Pacific		29		Biowaves, Inc.
Balaenoptera borealis	Sei whale	western tropical Pacific		4		Biowaves, Inc.
Balaenoptera edeni	Bryde's whale	eastern tropical Pacific	1402	12	364600	NOAA/CIMRS
		western tropical Pacific		2		Biowaves, Inc.
Balaenoptera musculus	blue whale	north Atlantic	405	9	1401	NOAA/CIMRS
Balaenoptera physalus	fin whale	north Atlantic	3066	15	75320	NOAA/CIMRS
Eschrichtius robustus	Gray whale	Baja Mexico	9697			Independent researcher
Eubalaena australis	southern right whale	South Africa	67	5	2273	Independent researcher
Eubalaena glacialis	north Atlantic right whale					NOAA/CIMRS
Eubalaena japonica	north Pacific right whale	Bering Sea	38	6	4496	NOAA/CIMRS
Megaptera novaeangliae	humpback whale	north Atlantic	2310	14	7600	NOAA/CIMRS
		western tropical Pacific		11		Biowaves, Inc
Odontocetes (toothed whales and dolphins) other than beaked whales						
Globicephala macrorhynchus	short-finned pilot whale	AUTEC, North Atlantic	55933	9	13500	NUWC
		north Atlantic, Canary Isls		1	2000	MEER e.V.
		northwestern Pacific		2		Biowaves, Inc
Globicephala malena	long-finned pilot whale	Mediterranean		16		Univ. Pavia, Italy
Grampus griseus	Risso's Dolphins	SCORE, Southern Calif.		10	17100	SIO
		Mediterranean		6		Univ. Pavia, Italy
Peponocephala electra	Melon-headed whale	northwestern Pacific		1		Biowaves, Inc.
Physeter macrochephalus	sperm whale	AUTEC, North Atlantic		3	2790	NUWC
		western tropical Pacific		61		Biowaves, Inc.
		Mediterranean		6		Univ. Crete
Psuedorca crassidens	False killer whales	western tropical Pacific		10		Biowaves, Inc
Stenella attenuata	pantropical spotted dolphin	western tropical Pacific		11		Biowaves, Inc

Stenella coeruleoalba	Striped Dolphin	western tropical Pacific		9		Biowaves, Inc
Stenella longirostris	Spinner Dolphin	western tropical Pacific		1		Biowaves, Inc
Steno bredanensis	rough-toothed Dolphins	AUTEC, North Atlantic		2	3600	NUWC
		north Atlantic, Canary Isls		1	900	MEER e.V.
		western tropical Pacific		1		Biowaves, Inc.
Stenella spp.	spotted dolphin	AUTEC, North Atlantic		1	1800	NUWC
		north Atlantic, Canary Isls		1	900	MEER e.V.
Tursiops truncatus	bottlenose dolphins	north Atlantic, Canary Isls		1	900	MEER e.V.
		western tropical Pacific		1		Biowaves, Inc
Odontocetes- beaked whales						
Berardius arnuxii	Arnoux's Beaked Whale	Antarctic	3379	3	8409	Univ. New S. Wales
Berardius bairdii	Baird's Beaked Whale	north Pacific		21	7233	NMML/APL/NOAA
		Baja Mexico		60	3600	NMML/NOAA
Mesoplodon densirostris	Blainville's Beaked Whale	AUTEC, North Atlantic	3637	41	67613	AUTEC
		north Atlantic, Canary Isls.	3000	1	1260	WHOI
		eastern tropical Pacific		3	19.7	NOAA
Mesoplodon spp	Beaked whales	western tropical Pacific		4		Biowaves, Inc.
Ziphius cavirostris	Cuvier's Beaked Whale	Mediterranean	3137	1	1800	WHOI
		Mediterranean		10		Univ. Pavia, Italy
Pinnipeds (seals)						
Lobodon carcinophaga	crabeater seals	Antarctic	3940	714	42840	PALAOA
Hydrurga leptonyx	leopard seal	Antarctic	7249	3923	235440	PALAOA
Erignathus barbatus	bearded seal	northern Alaska		2	1000	Greenridge Sciences, Inc.
EXTANT: available but not yet added to the archive						
Mysticetes (Baleen whales)						
Balaenoptera acutorostrata	Minke whale	eastern tropical Pacific				Bio-Waves Inc.
Megaptera novaeangliae	humpback whale	north Atlantic				OASIS, Inc
		eastern tropical Pacific				Bio-Waves Inc.
Odontocetes (toothed whales and dolphins)- beaked whales						
Delphinus capensis	long-beaked common dolphin	SCORE, Southern Calif				SIO
Delphinus delphis	short-beaked common dolphin	SCORE, Southern Calif.				SIO
Orcinus orca	killer whales	Southern Puget Sound				Independent Researcher
Physeter macrocephalluss	sperm whale	Mediterranean				Univ. Crete
		Gulf of Mexico				Univ. New Orleans
Pinnipeds (seals)						
Phoca vitulina	harbor seals	California coastline				NMFS/NOAA

*Abbreviations:

AUTEC	Atlantic Undersea Test and Evaluation Center	PALAOA	Perennial Acoustic Observatory in the Antarctic Ocean
CIMRS	Cooperative Institute for Marine Resources Studies	SCORE	Southern California Offshore Range
NMML	National Marine Mammal Laboratory	SIO	Scripps Institution of Oceanography
NOAA	National Oceanic and Atmospheric Administration	UW-APL	University of Washington, Applied Physics Laboratory
NUWC	Naval Undersea Warfare Center	WHOI	Woods Hole Oceanographic Institution

Appendix 2:

Open access website www.mobysound.org

Appendix 3.

Publications and Presentations.

Publications

Bogue, N. M., J. C. Luby, W. A. Jump, J. M. Pyle, G. B. Shilling, T. Litchendorf, A. S. Wood, D. K. Mellinger, and H. Klinck. **2009**. Passive acoustic monitoring using Seaglider: initial deployments. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 52-53*.

Klinck, H. and D. K. Mellinger. **In review**. The Energy Ratio Mapping Algorithm (ERMA): a tool to improve the energy-based detection of odontocete clicks. *Submitted to*: Journal of the Acoustical Society of America.

Klinck, H., and D. K. Mellinger. **2009**. A real-time detection system for odontocete echolocation clicks in the low-energy processing environment of an acoustic glider. J. Acoust. Soc. Am. **125(4)**:*2548(A)*.

Klinck, H., D. K. Mellinger, N. M. Bogue, J. C. Luby, W. A. Jump, J. M. Pyle, and G. B. Shilling. **2009**. Autonomous passive acoustic monitoring of marine mammals using the Seaglider: onboard real-time detection and classification of target signals. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *p. 86*.

Klinck, H., D. K. Mellinger, S. Heimlich, and S. Nieukirk. **2008**. The Energy Ratio Mapping Algorithm (ERMA): A tool to improve the energy-based detection of odontocete clicks. Book of Extended Abstracts, Second International Conference on Acoustic Communication by Animals, *pp. 119-120*.

Klinck, H., D. K. Mellinger, K. Klinck, J. Hager, L. Kindermann, and O. Boebel. **2010**. Underwater calls of the crabeater seal (*Lobodon carcinophaga*). J. Acoustic Soc. Am. **128**: *474-479*.

Klinck, H., R. Stelzer, K. Jafarmadar, and D. K. Mellinger. **2009**. AAS Endurance: An Autonomous acoustic sailboat for marine mammal research. Proceedings of the International Robotic Sailing Conference (IRSC). Matosinhos, Portugal, July 2009, *pp. 43-48*.

Kreiss, C. M., I. C. Van Opzeeland, H. Klinck, H. Bornemann, L. Kindermann, H. Figueroa, T. L. Rogers, J. Ploetz, and O. Boebel. **In review**. Leopard seal (*Hydrurga leptonyx*) vocalizations from three different Antarctic locations. *Submitted to*: Marine Mammal Science.

Küsel, E. T., D. K. Mellinger, L. Thomas, T. A. Marques, D. Moretti, and J. Ward. **In prep**. Development of method for cetacean density estimation from single fixed sensors using passive acoustics.

Martin, S. W., T. A. Marques, L. Thomas, D. Moretti, R. Morrissey, N. DiMarzio, S. Jarvis, and D. K. Mellinger. **2009**. Estimating minke whale boing density at Pacific Missile Range Facility, Hawaii. *Symposium:* Estimating Cetacean Density from Passive Acoustics, La Jolla, July 2009, *p. 8*.

Matsumoto, H., C. Jones, H. Klinck, D. K. Mellinger, L. Williams, C. Meinig, and R. P. Dziak. **2010**. The QUEphone: a passive acoustic float for marine mammal monitoring. Abstract **BO45G-02**, Ocean Sciences Meeting, Portland, Feb. 22-26, 2010.

Matsumoto, H., C. D. Jones, D. K. Mellinger, and R. P. Dziak. **2009**. Acoustic float for marine mammal monitoring. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 70-71*.

Mellinger, D. K. **2009**. Automatic detection for long-term monitoring of marine organisms. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 54-55*.

Mellinger, D. K., D. Gillespie, C. Clark, and A. Thode. **2009**. Signal processing overview. *Presentation Abstracts*: Acoustic Monitoring and Mitigation Systems: Status and Applications for Use by Regulated Offshore Industries. Minerals Management Service, Nov. 17-19, 2009, Boston, *pp 14-15*.

Mellinger, D. K., D. Gillespie, H. Figueroa, K. Stafford, and T. Yack. **2009**. Software for bioacoustic analysis of passive acoustic data. J. Acoust. Soc. Am. **125(4)**: *2547(A)*.

Mellinger, D. K., H. Klinck, N. M. Bogue, J. C. Luby, W. A. Jump, J. M. Pyle, G. B. Shilling, T. Litchendorf, and A. S. Wood. **2010**. Ocean gliders for acoustic observation of marine mammals. Abstract **BO44B-01**, Ocean Sciences Meeting, Portland, Feb. 22-26, 2010.

Mellinger, D. K., H. Klinck, S. Heimlich, and S. Nieukirk. **2008**. Annotated odontocete recordings for developing automated detection and classification methods. J. Acoust. Soc. Am. **123(5)**:*3362(A)*.

Mellinger, D. K., S. W. Martin, J. Yosco, R. P. Morrissey, N. A. DiMarzio, D. J. Moretti, and L. Thomas. **2009**. An algorithm for detection of whistles, moans, and other tonal sounds. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 48*.

Mellinger, D. K., R. P. Morrissey, S. W. Martin, L. Thomas, T. A. Marques, J. Yosko. **In prep**. A method for detecting whistles, moans, and other frequency contours.

Moore, S. E., K. M. Stafford, D. K. Mellinger, and C. W. Clark. **In review**. Insights into large whale ecology from broad-scale passive acoustic sampling. *Submitted to*: Marine Ecology Progress Series.

Morrissey, R. P., N. A. DiMarzio, D. J. Moretti, S. W. Martin, D. K. Mellinger, J. Yosco, C. Ciminello, and L. Thomas. **2009**. Passive acoustic detection of Minke whales (*Balaenoptera acutorostrata*) off the West Coast of Kauai, HI. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 57*.

Nieukirk, S. L., D. K. Mellinger, S. E. Moore, K. Klinck, and R. P. Dziak. **In prep**. Seismic airgun sounds and fin whale vocalizations recorded in the mid-Atlantic Ocean.

Roch, M., Y. Barkley, S. Baumann-Pickering, J. A. Hildebrand, P. Hursky, H. Klinck, D. K. Mellinger, B. Patel, M. Porter, S. Qui, S. Rankin, M. Soldevilla, and S. M. Wiggins. **2009**. Acoustic detections and how to manage them. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 62-63*.

Roch, M. A., H. Klinck, D. K. Mellinger, S. Baumann-Pickering, M. S. Soldevilla, M. McDonald, and J. A. Hildebrand. **In press**. Classification of odontocetes in the Southern California Bight through the use of echolocation clicks. *Submitted to*: Journal of the Acoustical Society of America.

Roch, M., H. Klinck, D. K. Mellinger, M. S. Soldevilla, and J. A. Hildebrand. **2009**. Flexible spatiotemporal databases for marine mammal observations. Proc. 16th Biennial Conf. Biol. Mar. Mamm., Oct. 12-16, 2009, Québec, *p. 217*.

Roch, M. A., H. Klinck, D. K. Mellinger, M. S. Soldevilla, J. A. Hildebrand. **2008**. Comparison of feature extraction methods for the identification of odontocete species based upon echolocation clicks. J. Acoust. Soc. Am. **123(5)**:*3100(A)*.

Sagen, H., S. Sandven, A. Beszczynska-Moeller, O. Boebel, T. F. Duda, L. Freitag, J. C. Gascard, A. Gavrilov, C. M. Lee, D. K. Mellinger, P. Mikhalevsky, S. Moore, A. K. Morozov, M. Rixen, E. Skarsoulis, K. Stafford, E. Tveit, and P. F. Worcester. **2009**. Acoustic technologies for observing the interior of the Arctic Ocean. Proc. OceanObs'09, 21-25 September 2009, Venice.

Stafford, K. M., S. E. Moore, P. J. Stabeno, D. V. Holliday, J. M. Napp, and D. K. Mellinger. **In press**. Biophysical ocean observation in the southeastern Bering Sea. *Submitted to*: Geophys. Rev. Lett.

Van Opzeeland, I., S. Van Parijs, H. Bornemann, S. Frickenhaus, L. Kindermann, H. Klinck, J. Plötz, and O. Boebel. **2010**. Acoustic ecology of Antarctic pinnipeds. Marine Ecology Progress Series **414**: *267-291*.

Yack, T. M., J. Barlow, M. A. Roch, H. Klinck, S. Martin, D. K. Mellinger, and D. Gillespie. **In prep**. Comparison of beaked whale detection algorithms.

Yack, T. M., J. Barlow, M. A. Roch, H. Klinck, S. Martin, D. K. Mellinger, and D. Gillespie. **2009**. Comparison of beaked whale detection algorithms. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 28*.

Invited talks, oral and poster presentations

Bogue, N. M., J. C. Luby, W. A. Jump, J. M. Pyle, G. B. Shilling, T. Litchendorf, A. S. Wood, D. K. Mellinger, and H. Klinck. **2009**. Passive acoustic monitoring using Seaglider: initial deployments. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 52-53*.

Constantinou, N., H. Klinck, T. L. Rogers, S. Laffan, D. K. Mellinger, R. P. Dziak, and M. Park. **2010**. Can passive-acoustics identify the driving factors behind changes in marine mammal abundance and distribution? 20th International Congress on Acoustics, Sydney, Australia, 23-28 August 2010.

Cowles, T. J., K. Benoit-Bird, and D. K. Mellinger. **2009**. Factors influencing the acoustic behavior and nearshore residence of the gray whale (*Eschrichtius robustus*) along their migration route. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 104-105*.

Gillespie, D., J. Gordon, D. McLaren, D. K. Mellinger, P. Redmond, A. Thode, R. McHugh, P. Trinder, X.-Y. Deng, and C. Blight. **2009**. PAMGUARD: Semi-automated open-source software for real-time acoustic detection and localisation of cetaceans. 23rd Annual Meeting of the European Cetacean Society, Istanbul.

Gillespie, D., D. K. Mellinger, J. Gordon, D. McLaren, P. Redmond, R. McHugh, P. Trinder, X.-Y. Deng, and A. Thode. **2009**. PAMGUARD: Semi-automated, open source software for real-time acoustic detection and localization of cetaceans. J. Acoust. Soc. Am. **125(4)**: *2547(A)*.

Glaeser, S. S., H. Klinck, D. K. Mellinger, Y. Ren, P. J. Clemins, M. T. Johnson, M. L. H. Cook, and R. Zelick. **2009**. A vocal repertoire of Asian elephants (*Elephas maximus*) and comparison of call classification methods. J. Acoust. Soc. Am. **125(4)**: *2710(A)*.

Heimlich, S. L., D. K. Mellinger, H. Klinck, K. Stafford, S. E. Moore, C. Berchok, and S. L. Nieukirk. **2009**. Detecting bowhead whale (*Balaena mysticetus*) sounds in the Beaufort Sea: confounding sounds in a cacophony of noise. Proc. 16th Biennial Conf. Biol. Mar. Mamm., Oct. 12-16, 2009, Québec, *pp. 110-111*.

Heimlich, S. L., D. K. Mellinger, S. L. Nieukirk, H. Klinck, K. Stafford, S. E. Moore, and P. J. Stabeno. **2009**. Detecting humpback whale sounds in the Bering Sea: Confounding sounds in a cacophony of noise. J. Acoust. Soc. Am. **125(4)**: *2647(A)*.

Klinck, H., N. Constantinou, D. K. Mellinger, and R. Tracey. **2010**. Density estimation of leopard seals using a single stationary passive acoustic sensor. 159th Meeting of the Acoustical Society of America, Baltimore, USA, 19-23 April 2010.

Klinck, H., L. Kindermann, D. K. Mellinger, and O. Boebel. **2009**. Screening large data sets and real-time data streams for bioacoustic signals. 157th Meeting of the Acoustical Society of America, Portland, USA, 18-22 May 2009. J. Acoust. Soc. Am. **125(4)**: *2587(A)*.

Klinck, H., and D. K. Mellinger. **2009**. A real-time detection system for odontocete echolocation clicks in the low-energy processing environment of an acoustic glider. J. Acoust. Soc. Am. **125(4)**: *2548(A)*.

Klinck, H., D. K. Mellinger, N. Bogue, J. Luby, B. Jump, J. Pyle, and G. Shilling. **2009**. An autonomous ocean glider using real-time acoustic detection and classification of marine mammal sounds. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 50*.

Klinck, H., D. K. Mellinger, N. M. Bogue, J. C. Luby, W. A. Jump, J. M. Pyle, and G. B. Shilling. **2009**. Autonomous passive acoustic monitoring of marine mammals using the Seaglider: onboard real-time detection and classification of target signals. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *p. 86*.

Klinck, H., R. Stelzer, K. Jafarmadar, and D. K. Mellinger. **2009**. AAS Endurance: An autonomous acoustic sailboat for marine mammal research. International Robotic Sailing Conference, Matosinhos, Portugal, 6-12 July 2009.

Küsel, E. T., D. K. Mellinger, L. Thomas, T. Marques, D. Moretti, and J. Ward. **2009**. Estimating beaked whale density from single hydrophones by means of propagation modeling. *Symposium:* Estimating Cetacean Density from Passive Acoustics, La Jolla, July 2009, *p. 3*.

Küsel, E. T., D. Mellinger, L. Thomas, T. A. Marques, D. J. Moretti, and J. Ward. **2009**. Beaked whale density estimation from single hydrophones by means of propagation modeling. J. Acoust. Soc. Am. **125(4)**: *2589(A)*.

Küsel, E. T., D. K. Mellinger, L. Thomas, T. A. Marques, D. J. Moretti, and J. Ward. **2009**. Density estimation of Blainville's beaked whales (*Mesoplodon densirostris*) from single hydrophones by means of propagation modeling. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 78*.

Küsel, E. T., D. K. Mellinger, L. Thomas, T. A. Marques, D. J. Moretti, and J. Ward. **2009**. Estimating beaked whale density from single hydrophones by means of propagation modeling. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *p. 87*.

Marques, T. A., L. Thomas, S. W. Martin, D. K. Mellinger, S. Jarvis, N. DiMarzio, and R. P. Morrissey. **2009**. Spatially explicit capture-recapture methods to estimate minke whale abundance from data collected at bottom mounted hydrophones. Proc. EURING 2009, 14-20 Sept. 2009, Pescara, Italy.

Martin, S. W, T. A. Marques, L. Thomas, D. Moretti, R. Morrissey, N. DiMarzio, S. Jarvis, and D. K. Mellinger. **2009**. Estimating minke whale boing density at Pacific Missile Range Facility, Hawaii. *Symposium:* Estimating Cetacean Density from Passive Acoustics, La Jolla, July 2009, *p. 8*.

Matsumoto, H., C. D. Jones, D. K. Mellinger, and R. P. Dziak. **2009**. Acoustic float for marine mammal monitoring. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 70-71*.

Mellinger, D. K. **2009**. Automatic detection for long-term monitoring of marine organisms. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 54-55*.

Mellinger, D. K. **2009**. Noise-resistant acoustic measurements implemented in user-friendly software. J. Acoust. Soc. Am. **125(4)**: *2737(A)*.

Mellinger, D. K., D. Gillespie, C. Clark, and A. Thode. **2009**. Signal processing overview. *Presentation Abstracts*: Acoustic Monitoring and Mitigation Systems: Status and Applications for Use by Regulated Offshore Industries, Minerals Management Service, Nov. 17-19, 2009, Boston, *pp 14-15*.

Mellinger, D. K., D. Gillespie, H. Figueroa, K. Stafford, and T. Yack. **2009**. Software for bioacoustic analysis of passive acoustic data. J. Acoust. Soc. Am. **125(4)**: *2547(A)*.

Mellinger, D. K., H. Klinck, N. M. Bogue, J. C. Luby, W. A. Jump, J. M. Pyle, G. B. Shilling, T. Litchendorf, and A. S. Wood. **2010**. Ocean gliders for acoustic observation of marine mammals. 2010 Ocean Sciences Meeting, Portland, USA, 22-26 February 2010.

Mellinger, D. K., H. Klinck, S. L. Heimlich, and S. L. Nieukirk. **2009**. Annotated odontocete recordings for developing automated detection and classification methods. 157th Meeting of the Acoustical Society of America, Portland, USA, 18-22 May 2009.

Mellinger, D. K., E. Küsel, L. Thomas, and T. Marques. **2009**. Taming the Jez monster: Estimating fin whale spatial density using acoustic propagation modeling. J. Acoust. Soc. Am. **126(4)**: *2229(A)*.

Mellinger, D. K., S. W. Martin, J. Yosco, R. P. Morrissey, N. A. DiMarzio, D. J. Moretti, L. Thomas. **2009**. An algorithm for detection of whistles, moans, and other tonal sounds. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 48*.

Mellinger, D. K., S. L. Nieukirk, K. Klinck, H. Klinck, R. P. Dziak, and P.J. Clapham. **2009**. Acoustic rediscovery of right whales in a former whaling area, the Cape Farewell Ground, between Greenland and Iceland. J. Acoust. Soc. Am. **125(4)**: *2617(A)*.

Mellinger, D. K., S. L. Nieukirk, K. Klinck, H. Klinck, R. P. Dziak, M. Fowler, P. J. Clapham, and B. Brandsdóttir. **2009**. Right whales rediscovered off Greenland. Proc. 16th Biennial Conf. Biol. Mar. Mamm., Oct. 12-16, 2009, Québec, *p. 164*.

Mellinger, D. K., K. M. Stafford, S. E. Moore, S. L. Nieukirk, S. L. Heimlich, and P. J. Stabeno. **2009**. Passive acoustic detection of right, fin and humpback whales in the eastern Bering Sea. Oral Presentations and Posters, Alaska Marine Sci. Symposium 2009, Anchorage, Jan. 2009.

Morrissey, R. P., N. A. DiMarzio, D. J. Moretti, S. W. Martin, D. K. Mellinger, J. Yosco, C. Ciminello, and L. Thomas. **2009**. Passive acoustic detection of Minke whales (*Balaenoptera acutorostrata*) off the West Coast of Kauai, HI. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 57*.

Nieukirk, S. L., S. L. Heimlich, S. E. Moore, K. M. Stafford, R. P. Dziak, M. Fowler, J. Haxel, J. Goslin, and D. K. Mellinger. **2009**. Whales and airguns: An eight-year acoustic study in the central North Atlantic. Proc. 16th Biennial Conf. Biol. Mar. Mamm., Oct. 12-16, 2009, Québec, *pp. 181-182*.

Nieukirk, S. L., D. K. Mellinger, S. E. Moore, K. Klinck, S. L. Heimlich, and H. Klinck. Seismic airgun sounds recorded in the North Atlantic. J. Acoust. Soc. Am. **125(4)**: *2518(A).*

Olmstead, T. J., M. A. Roch, P. Hursky, M. B. Porter, H. Klinck, D. K. Mellinger, T. Helble, S. M. Wiggins, G. L. D'Spain, and J. A. Hildebrand. **2009**. Autonomous underwater glider based embedded real-time marine mammal detection and classification. 157th Meeting of the Acoustical Society of America, Portland, USA, 18-22 May 2009.

Roch, M., Y. Barkley, S. Baumann-Pickering, J. A. Hildebrand, P. Hursky, H. Klinck, D. K. Mellinger, B. Patel, M. Porter, S. Qui, S. Rankin, M. Soldevilla, and S. M. Wiggins. **2009**. Acoustic detections and how to manage them. Book of abstracts, ONR Marine Mammal Program Review, Dec. 7-10, 2009, Alexandria, VA, *pp. 62-63*.

Roch, M., H. Klinck, D. K. Mellinger, M. S. Soldevilla, and J. A. Hildebrand. **2009**. Flexible spatiotemporal databases for marine mammal observations. Proc. 16th Biennial Conf. Biol. Mar. Mamm., Oct. 12-16, 2009, Québec, *p. 217*.

Roch, M. A., H. Klinck, D. K. Mellinger, M. S. Soldevilla, and J. A. Hildebrand. **2008**. Comparison of feature extraction methods for the identification of odontocete species based upon echolocation clicks. 155th Meeting of the Acoustical Society of America, Acoustics '08, Paris, France, 30 June - 4 July 2008.

Stafford, K. M., D. K. Mellinger, P. J. Stabeno, S. L. Nieukirk, S. L. Heimlich, and S. E. Moore. **2009**. Analysis of acoustic and oceanographic data from the Bering Sea June 2006-May 2007. Oral Presentations and Posters, Alaska Marine Sci. Symposium 2009, Anchorage, Jan. 2009.

Stafford, K., S. Moore, C. Berchok, and D. K. Mellinger. **2009**. Acoustic sampling for marine mammals in the Beaufort Sea July 2007-March 2008. J. Acoust. Soc. Am. **125(4)**: *2587(A).*

Yack, T. M., J. Barlow, M. A. Roch, H. Klinck, S. Martin, D. K. Mellinger, and D. Gillespie. **2009**. Comparison of beaked whale detection algorithms. Book of abstracts, Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics, Pavia, Italy, Sept. 10-13, 2009, *p. 28*.

Zerbini, A. N., P. J. Clapham, C. Berchok, A. Kennedy, B. Rone, D. K. Mellinger, S. L. Nieukirk, and S. E. Moore. **2009**. Occurrence of the endangered North Pacific right whale (*Eubalaena japonica*) in the Bering Sea in 2008. Oral Presentations and Posters, Alaska Marine Sci. Symposium 2009, Anchorage, Jan. 2009.

Internal reports

Matsumoto, H., C. Jones, D. K. Mellinger, and R. P. Dziak. **2009**. Acoustic float for marine mammal monitoring. Progress report for award N00014-08-1-1198, Office of Naval Research.

Mellinger, D. Automatic detection of beaked whales from acoustic Seagliders. Progress report for award N00014-08-1-1082, Office of Naval Research.

Data exchanges

Alfred Wegener Institute – crabeater seal recordings from Antarctica.

Greenridge Sciences, Inc. – bowhead whale recordings from the eastern Beaufort Sea.

JASCO, Inc. – bowhead whale recordings form the Chukchi Sea.

MEER (Mamiferos, Encuentros, Educación, Reconocimiento) – short-finned pilot whale recordings from the Canary Islands.

NOAA-NMML – recordings of many species from the Bering Sea.

Univ. Crete – sperm whales from the Mediterranean Sea.

Univ. New South Wales – Arnoux's beaked whale recordings from Antarctica.

Dissertations/graduate theses

None.

Initial Distribution List

1.	Defense Technical Information Center 8725 John J. Kingman Rd., STE 0944 Ft. Belvoir, VA 22060-6218	2
2.	Dudley Knox Library, Code 013 Naval Postgraduate School Monterey, CA 93943-5100	2
3.	Erin Oleson National Marine Fisheries Service Pacific Islands Fisheries Science Center Honolulu, HI	1
4.	John Hildebrand Scripps Institution of Oceanography University of California La Jolla, CA	1
5.	John Calambokidis Cascadia Research Collective Olympia, WA	1
6.	Greg Schorr Cascadia Research Collective Olympia, WA	1
7.	Erin Falcone Cascadia Research Collective Olympia, WA	1
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9.	Curtis A. Collins Naval Postgraduate School Monterey, CA	1
10.	Thomas A. Rago Naval Postgraduate School Monterey, CA	1

11.	Tetyana Margolina Naval Postgraduate School Monterey, CA	1
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13.	John Joseph Naval Postgraduate School Monterey, CA	1
14.	Katherine Whitaker Pacific Grove, CA	1
15.	Frank Stone CNO(N45) Washington, D.C.	1
16.	Jay Barlow Southwest Fisheries Science Center, NOAA La Jolla, CA	1
17.	CAPT Ernie Young, USN (Ret.) CNO(N45) Washington, D.C.	1
18.	Dale Liechty CNO(N45) Washington, D.C.	1
19.	Dave Mellinger Oregon State University Newport, OR	1
20.	Kate Stafford Applied Physics Laboratory University of Washington Seattle, CA	1
21.	Sue Moore NOAA at Applied Physics Laboratory University of Washington Seattle, WA	1

22.	Petr Krysl University of California La Jolla, CA	1
23.	Mark McDonald Whale Acoustics Bellvue, CO	1
24.	Ted Cranford San Diego State University San Diego, CA	1
25.	Monique Fargues Naval Postgraduate School Monterey, CA	1
26.	Mary Ann Daher Woods Hole Oceanographic Institution Woods Hole, MA	1
27.	Heidi Nevitt NAS North Island San Diego, CA	1
28.	Rebecca Stone Naval Postgraduate School Monterey, CA	1
29.	Melissa Hock Scripps Institution of Oceanography University of California La Jolla, CA	1
30.	Sean M. Wiggins Scripps Institution of Oceanography University of California La Jolla, CA	1
31.	E. Elizabeth Henderson Scripps Institution of Oceanography University of California La Jolla, CA	1

32.	Gregory S. Campbell Scripps Institution of Oceanography University of California La Jolla, CA	1
33.	Marie A. Roch San Diego State University San Diego, CA	1
34.	Anne Douglas Cascadia Research Collective Olympia, WA	1
35.	Julie Rivers COMPACFLT Pearl Harbor, HI	1
36.	Jenny Marshall Naval Facilities Engineering Command San Diego, CA	1
37.	Chip Johnson COMPACFLT Pearl Harbor, HI	1
38.	CDR Len Remias U.S. Pacific Fleet Pearl Harbor, HI	1
39.	LCDR Robert S. Thompson U.S. Pacific Fleet Pearl Harbor, HI	1
40.	Jene J. Nissen U. S. Fleet Forces Command Norfolk, VA	1
41.	W. David Noble U. S. Fleet Forces Command Norfolk, VA	1
42.	David T. MacDuffee U. S. Fleet Forces Command Norfolk, VA	1

43.	Keith A. Jenkins Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
44.	Joel T. Bell Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
45.	Mandy L. Shoemaker Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
46.	Anurag Kumar Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
47.	Merel Dalebout University of New South Wales Sydney, Australia	1
48.	Robin W. Baird Cascadia Research Collective Olympia, WA	1
49.	Brenda K. Rone National Marine Mammal Laboratory Seattle, WA	1
50.	Phil Clapham National Marine Mammal Laboratory Seattle, WA	1
51.	Laura J. Morse National Marine Mammal Laboratory Seattle, WA	1
52.	Anthony Martinez NOAA Southeast Fisheries Science Center Miami, FL	1
53.	Darlene R. Ketten Woods Hole Oceanographic Institution Woods Hole, MA	1

54.	David C. Mountain Boston University Boston, MA	1
55.	Melissa Soldevilla Duke University Durham, NC	1
56.	Brandon L. Southall Southall Environmental Associates, Inc. Santa Cruz, CA	1
57.	David Moretti NUWC Newport, RI	1
58.	Michael Weise Office of Naval Research, Code 32 Arlington, VA	1
59.	Dan Costa University of California, Santa Cruz Santa Cruz, CA	1
60.	Lori Mazzuca Marine Mammal Research Consultants, Inc. Honolulu, HI	1
61.	Jim Eckman Office of Naval Research Arlington, VA	1
62.	Ari Friedlaender Duke University Beaufort, NC	1
63.	CAPT Robin Brake U.S. Navy Washington, DC	1
64.	Mary Grady Southwest Fisheries Science Center La Jolla, CA	1

65.	Lisa Ballance Southwest Fisheries Science Center La Jolla, CA	1
66.	Angela D'Amico SPAWAR San Diego, CA	1
67.	Amy Smith Science Applications International Corporation McLean, VA	1
68.	Peter Tyack Woods Hole Oceanographic Institution Woods Hole, MA	1
69.	Ian Boyd University of St. Andrews St. Andrews, Scotland, UK	1
70.	Simone Baumann-Pickering Scripps Institution of Oceanography University of California La Jolla, CA	1
71.	Lisa K. Baldwin Scripps Institution of Oceanography University of California La Jolla, CA	1
72.	Anne E. Simonis Scripps Institution of Oceanography University of California La Jolla, CA	1
73.	Mariana L. Melcon Scripps Institution of Oceanography University of California La Jolla, CA	1
74.	Daniel L. Webster Cascadia Research Collective Olympia, WA	1

75.	Daniel J. McSweeney Wild Whale Research Foundation Holualoa, HI	1